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PROTEIN CONTENT OF THE ATMOSPHERE

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Robert A. Taft Sanitary Engineering Center
Cincinnati, Ohio

1958

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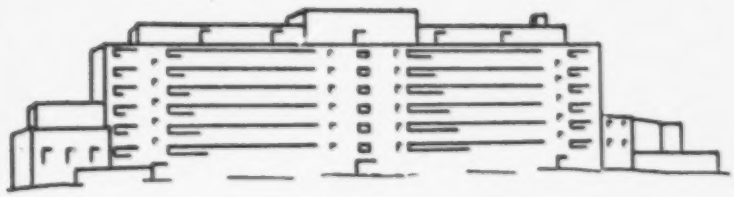

PROTEIN CONTENT OF THE ATMOSPHERE

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U.S. DEPARTMENT OF HEALTH,
EDUCATION, AND WELFARE
Public Health Service

1958

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PROTEIN CONTENT OF THE ATMOSPHERE

This report is based on a study conducted
April 1953 - July 1955

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U. S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
Public Health Service
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Division of Sanitary Engineering Services

Robert A. Taft Sanitary Engineering Center
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PROTEIN CONTENT OF THE ATMOSPHERE

INTRODUCTION

As a part of the general air pollution program conducted by the Robert A. Taft Sanitary Engineering Center, a study was made of the protein content of the atmosphere. This may be of some importance in a study of allergens and indicative of certain sources of air pollution. Sampling stations were located at selected points throughout the continental United States and Alaska (Fig.1).

The objectives of the investigation were: (1) development of an analytical method suitable for determining protein content in the presence of normal air contaminants; and (2) frequent air sampling to determine the variation of the protein concentration as a function of time and of height above ground.

ANALYTICAL METHODS

REMOVAL OF INTERFERING ORGANIC MATERIALS

It was recognized in the beginning that since airborne particulate matter consists of a complex mixture of inorganic and organic materials, an initial extraction would be necessary to remove interfering organic materials. An eight-hour extraction with acetone eliminated a maximum amount of nonprotein organic matter with little if any loss of protein. Extraction with acetone was adopted as a standard treatment for all particulate samples to be analyzed for protein content.

ISOLATION OF PROTEIN FROM AIR PARTICULATE MATTER BY HYDROLYSIS

Since characteristics of proteins in airborne particulate matter were unknown, a method insuring quantitative removal of such protein from the filter had to be devised. Obviously no single solvent could be expected to dissolve quantitatively all the possible proteins; therefore, another approach was necessary. It was established that digestion of extracted particulate samples with acid for 20 to 24 hours resulted in a quantitative recovery of the proteins from the sample. As a result of preliminary studies, the following procedure was used for the hydrolysis of proteins found in the particulate samples; reflux the previously extracted sample for 20 hours with 80 ml 1:1 hydrochloric acid, cool, make total volume to 100 ml with distilled water, mix, and centrifuge. The clear supernatant solution containing amino acids was used for analysis.

NINHYDRIN METHOD FOR ESTIMATION OF AMINO ACIDS

The method of Troll & Cannan was adapted for the estimation of amino acids in the hydrolysates of the particulate samples. The procedure was as follows:

1. To 0.4 ml of the hydrolysate add 1 ml of pyridine-KCN reagent (98 ml pyridine plus 2 ml 0.01 N KCN) and 1 ml phenol in ethanol (80 gms phenol plus 20 ml abs. ethanol).

2. Heat in a boiling water bath to bring temperature of solution to 100° then add 0.2 ml of 5% ninhydrin in absolute ethanol. Mix. Continue heating in boiling water for 5 min. Cool.

3. Dilute to 10 ml with 60% ethanol. Mix.

4. Read in spectrophotometer at 570 mμ against a reagent blank.

5. Obtain protein value from calibration curve.

In the preliminary study of the method it was found that the final solutions from the hydrolysates gave transmittance curves practically identical with those obtained from hydrolysates prepared by the same procedure from egg albumin, gelatin and casein. All showed absorption maxima at 570 mμ. This was a good indication that a mixture of amino acids was present in the hydrolysates from the air pollutants. Before the method could be used it was necessary to select a standard to be used in the calibration of the spectrophotometer. Crystalline egg albumin containing 15.4 percent nitrogen was selected as a primary standard as it appeared to be a representative protein, it contains a good sample of amino acids, is relatively easily prepared in a pure form, and is soluble. The decision was an arbitrary one based on the premise that when one is measuring protein it is better to use a protein as a standard.

STANDARDIZATION OF THE SPECTROPHOTOMETER

Solutions containing different amounts of egg albumin were hydrolyzed by boiling with hydrochloric acid as outlined above. Aliquots of 0.4 ml of the hydrolysates were carried through the procedure and readings were obtained on the spectrophotometer. This procedure was repeated several times to get consistent results for plotting a calibration curve.

MODIFICATIONS OF METHOD

It was necessary to remove any ammonia from the hydrolysates, because it would react with ninhydrin to give the same color as that given by amino acids, therefore leading to false high protein values. During the study the procedure for ammonia removal was improved. Three different methods were used, each in turn giving results more representative of the protein present and less influenced by presence of interfering materials.

1. A standard procedure for the removal of inorganic ammonia was first used. This consisted in boiling the previously extracted sample in a solution with pH 8-9 (phenolphthalein) until no further ammonia fumes could be detected. Then the hydrolytic procedure outlined above was followed. It was found later that hydrolysates prepared by this procedure contained excessively large amounts of ammonia apparently liberated from organic nitrogenous materials during hydrolysis. The amounts of ammonia found were much greater than could be attributed to proteins alone.

2. Since a large number of organic nitrogenous compounds are readily decomposed by boiling with fairly strong alkali resulting in the evolution of ammonia, whereas proteins are only slightly affected by such treatment, a method was devised which led to much more accurate protein values than obtained by Method I. The extracted sample was pretreated by boiling for 2 hours in a 0.5 N NaOH solution, acid was added, and the sample was then hydrolyzed by the procedure outlined above. Results obtained by this method appeared to be more representative than those obtained by Method I, since there were no exceptionally high values, but it was found that some hydrolysates still contained a greater quantity of ammonia than could arise from the protein itself.

3. It finally developed that the most satisfactory results were obtained by hydrolysis of the extracted sample without pretreatment for ammonia removal, followed by treatment for ammonia removal immediately prior to carrying out the ninhydrin reaction. This procedure, which was used for the major portion of the study, is as follows:

   a. Hydrolyze the sample as outlined.

   b. Evaporate a 10 ml portion of the hydrolysate to dryness on a steam bath to remove excess acid.

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c. Add 25-30 ml of distilled water and adjust the pH of the solution to 8.2 to 8.4 with N NaOH.

d. Evaporate the solution on steam bath to near dryness to remove ammonia.

e. Add 15-20 ml of water, adjust pH to 8.2 to 8.4 and again evaporate to near dryness.

f. Add 4 ml conc. HCl and dilute to 40 ml with distilled water.

g. Carry out the ninhydrin reaction and determine the protein content as previously outlined.

If this procedure is carefully followed all of the ammonia is removed and the amino acids remain unaltered, leading to values which more closely represent the true protein content of the samples than any obtained by the other methods.

SAMPLING METHODS

DEVELOPMENT OF SAMPLER AND SELECTION OF FILTERS

The high volume sampler developed by the Atomic Energy Commission appeared to be the most suitable for collection of samples. It had adequate capacity and was readily available in the required numbers for the project. A filter holder capable of accommodating rectangular 8"x10" filters was designed to fit the high volume sampler.

A wide variety of filter media were thoroughly investigated to find a filter meeting the following requirements of the project:

1. The filter medium should be composed of inert materials.

2. It should remove particles of 0.5 micron diameter and larger.

3. The finished filter should be free of organic and nitrogenous materials.

4. A filter should permit an initial flow rate of 40-60 cfm or filtration of a total volume of approximately 70,000 cu. ft. of air.

5. The filter medium must be suitable for use with the high volume sampler.

A rectangular glass fibre filter 8"x10", manufactured by the Hurlbut Company and distributed by Mine Safety Appliances Company, met the requirements and was adopted as the medium for use in this investigation.

The sampling equipment resulting from this development and used throughout the study consisted of an AEC-type high volume sampler to which was attached a stainless steel filter holder to accommodate the rectangular 8"x10" glass fiber filters (Fig. 2). The resulting effective filtration area was 7"x9" or 63 sq. in. This equipment sampled from 1500 to 2500 cubic meters of air in a 24-hour period, depending on the amount of particulate matter in the atmosphere. The filter, which contained no appreciable interfering materials, was practically 100% efficient in the removal of particles of 0.3 micron and greater in diameter. Adequate amounts of particulate matter were obtained for analysis.

ROUTINE SAMPLING PROCEDURES

The sampling program as set up called for the collection of at least one 24-hour sample a week at each of the sampling sites in a chosen area. In most communities selected to participate in this study at least two sampling sites were selected, one representative of the business area and the other of residential or rural conditions. The sampling sites, selected by representatives of the Robert A. Taft Sanitary Engineering Center, are listed and described in Table 1.

SPECIAL SAMPLING PROCEDURES

To achieve the objectives of the study it was required that samples be collected to determine (1) the vertical distribution of protein, (2) variation of the protein content of air as a function of time, and (3) protein-particle size relations.

1. High and low level sampling: Sampling programs at 2 or more different elevations at a single site were set up at Detroit (8 ft. and 150 ft.) Houston (18 ft., 50 ft., and 85 ft.) and Philadelphia (25 ft. and 236 ft.). Unfortunately, it was not possible to arrange for the collection of samples at any greater differences in elevation than those listed. Results of the analyses of the samples collected in this program are given in Table 13.

2. Short interval sampling: A sampling program was set up at three sites in Cincinnati for the collection of samples to

determine if there are any diurnal variations in the amount of protein in the atmosphere. The samplers - controlled by clocks - were set up to sample for periods of six hours instead of the usual 24. This sampling was carried out simultaneously at two sites in Cincinnati with the sampling periods coinciding as close as possible. It was not possible to set up identical sampling periods due to insufficient manpower and too great a distance between sampling sites. Whenever, possible, sampling was carried out continuously throughout the week. Results of the analyses of these samples are given in Table 11.

3. Sampling for particle size studies: Several samples of air particulate matter were collected with an Aerotec cyclone separator connected ahead of the high volume sampler. This resulted in the removal of the larger particles by the cyclone separator and the subsequent collection of the smaller particulates on the glass fiber filter in the usual manner. Since it was practically impossible to make a quantitative collection of the larger particles for analysis, another sampler was run in parallel in order to obtain a control sample containing both small and large particles. Thus, in each sampling period a composite sample and a sample consisting of the smaller particulates were obtained for comparison. It was not possible to assign specific particle sizes to each of the fractions as no facilities were available for the actual sizing of the collected particles. Results of the analyses of these samples are given in Table 12.

RESULTS

ROUTINE SAMPLING PROGRAM

A total of 1,698 samples, each comprising the particulate matter recovered from about 2000 cubic meters of air in 24 hours, were analyzed for protein content by one of the three methods. Of these, 459 were analyzed by Method I, 454 by Method II, and 785 by the more refined Method III.

A progressive improvement in specificity of the analytical procedure is indicated by the percentage of samples showing more than 5 µg of the protein per cubic meter in the groups analyzed by the three methods: method 1, 60 = 13.0%; method 2, 30 = 6.4%; and method 3, 8 = 1.0%. Furthermore, the maximum values of protein observed showed progressive and substantial decrease as the analytical procedure was developed: method I, 110.6 $\mu g/M^3$; method II, 19.0 $\mu g/M^3$; and method III, 6.4 $\mu g/M^3$.

Obviously the results by Method I were strongly affected by failure to remove ammonia completely; Method II constituted a substantial improvement in specificity which was apparently enhanced by adoption of Method III.

Unfortunately, it is not possible, on the basis of completed analyses, to conclude categorically that results by Method III are more accurate than those obtained with Method II, since the majority of samples analyzed by III were taken during the summer and fall quarters of the year, while most of those done by II were from the winter and spring quarters. Thus, there is a possibility, though rather remote, that the observed differences in maxima and high concentration levels (above 5 $\mu g/M^3$), may be partially or wholly related to the annual cycle. The quarterly distribution of samples analyzed by Methods II and III is given in Table 2.

The uncertainty is not resolved by examination of the relatively few cases in which analyses by both methods are available for the same localities during the same quarters of the year (Table 3). None of the high values obtained by Method II occurred in this selected group. The ranges of values, maxima, and averages show statistically insignificant differences; however, the small number of samples and substantial absence of time-coincidence between pairs of samples are such as to leave the question in doubt.

Since the significance of the difference in results obtained by Methods II and III is questionable and the observed difference small, data obtained by the two methods can be consolidated for the purpose of determining ranges of protein concentrations experienced during more than a full year of sampling. Table 4 shows the minimal, maximal, and average concentrations measured at individual stations, and the numbers of samples on which the data are based.

Since about 65% of the total samples considered in Table 4 were analyzed by the presumably superior Method III, it is of interest to record separately the results by this method alone (Table 5). The differences are striking and will have considerable significance if subsequent work proves them due to more exact procedure rather than to real seasonal variations in protein level. Actually only 5 of the 785 samples yielded protein values above 5 $\mu g/M^3$, only 2 above 6.0 $\mu g/M^3$, and none above 6.5. The probability of the occurrence of protein levels greater than 5 or 6 $\mu g/M^3$ under normal circumstances appears to be very small.

For those stations from which 10 or more samples were analyzed by Methods II and III, Table 6 ranks the stations by average protein level. An approximately 8-fold range of average protein concentration is revealed. It is probably significant that most of the stations situated in or near highly industrialized centers of population rank high, while the rural, lightly populated areas fall to the lower half of the ranking. Such a result is contrary to the hypothesis that most of the protein content of the air arises directly from vegetation and agricultural cycles. Evidently metropolitan activity is a heavy contributor.

A similar tabulation of data obtained by Method III only is presented in Table 7. All stations are included regardless of the number of samples analyzed. The range of average is 7-fold and the metropolitan-[illegible]an separation by rank of average concentration level is evident.

In order to establish the most frequent occurrences of particular protein levels, and especially to estimate the frequency of relatively high levels, tables have been constructed showing the indicated percentage of days during which a 24-hour sample showed values in each of 9 concentration intervals. Table 8 lists the stations according to their rank by average level from Table 6 and includes all data obtained by analytical Methods II and III.

A similar frequency table is presented in Table 9, this time including only data obtained by analytical Method III. Both of the frequency distribution tables emphasize the more usual occurrence of relatively higher values in major metropolitan areas than at rural or suburban sites.

The question of seasonal distribution of high and low values at a given station cannot, as has been indicated, be fully resolved with the data in hand. In Table 10 an attempt has been made to determine whether or not a seasonal distribution in average level by quarters of the year could be discerned for any or all of the stations. The table is based on data from Methods II and III, with values obtained from Method I included parenthetically to fill in some of the numerous gaps. The value for the quarter of the year showing the highest average protein level is underlined.

From this table the highest quarterly averages appear to be distributed in the following manner with respect to the number of stations: spring, 21; summer, 5; fall, 18; and winter 3. Since the winter quarter includes "spring" in deep South and the fall quarter includes late summer in the South and on the Pacific Coast,

some adjustment of the indicated distribution is possible. Two of the winter maxima are from the deep South, 9 fall maxima in the South, and 4 fall maxima on the Pacific Coast. Appropriate readjustment yields a seasonally corrected distribution of maxima as follows: spring, 23; summer, 18; fall, 5 (Philadelphia and Cincinnati); and winter, 1. In spite of the incomplete data, it seems reasonably certain that higher average levels occur during the periods of plant growth and harvest. In fact, it would be strange if such a trend were not discernible.

SPECIAL SAMPLING PROGRAM

1. Short-Time Sampling for Diurnal Variations.

A limited number of samples were collected at quarter-day intervals during consecutive days at three sites in Cincinnati. The purpose of the quarter-day sampling was to determine what, if any, diurnal variations in protein concentration occurred.

Table 11 gives the results. The data, while insufficient for trustworthy interpretation, show very little evidence of a diurnal cycle in protein concentration, except in the first three-day series (4/11-4/15). This group showed about twice as much protein during the daylight hours as was found at night. This trend may be presented in the final series tabulated but is not so obvious.

2. Particle Size Studies.

Simultaneously, samplers preceded in series by Aerotec Cyclone separators, alleged to cut out essentially all particles larger than about 5 microns diameter, were operated at the same sites. The Aerotec separations were performed in an effort to estimate very approximately the distribution of protein in the two size fractions.

The percentage of the total protein load contained in the smaller size fraction of collectible particulates is shown in Table 12. Day-to-day variations in this value were rather large and the variations in protein level were within about the same range as was found to obtain with respect to the total of particulate matter. In any event, it appears that an average of 38% of the total protein may occur in the fraction below approximately 5 microns diameter, with a range of values from 11.1% to 72% being obtained in the same series of collections. Considerably more refined separatory procedures will be required to establish the relationship of the protein concentration to particle size with any certainty.

3. Influence of Elevation.

Table 13 shows the results of analysis of the limited number of samples collected simultaneously at two different elevations at the same sampling site. No significant differences were shown between protein levels at the two elevations. At first glance it might appear that in the case of the Detroit samples the difference was of some significance; however, in this case the analyses were by Method I which unfortunately did not give true protein values. It was not possible to obtain further samples from Detroit during the latter months of the project; therefore, it was not possible to verify or invalidate the results obtained in the first months of the study. It was very difficult to set up sampling programs for this phase of the study because of the difficulties encountered in obtaining sampling sites with sufficiently great differences in elevation.

RELATION BETWEEN LEVELS OF PROTEIN AND ACETONE SOLUBLE MATERIALS

An attempt has been made to determine the relationship, if any, between the observed protein concentrations of the air sampled at the several stations, and the content of acetone extractable material. The following Tables (14, 15, 16, 17, 18) are representative of the range of relationships found, and demonstrate clearly that the two types of air pollutants are not correlated in their occurrence.

SUMMARY

A study was carried out to determine the protein content of airborne particulate matter. Utilizing a modified version of a commercially available high volume sampler and a glass fiber filter medium for collection, a nationwide sampling program was inaugurated. Active sampling was carried out at 67 locations in 21 communities. In most areas at least two sampling sites were used, one representing a business section and the other a residential or rural section. Attempts were made to obtain at least one sample per week at each site.

The standard ninhydrin reaction for measurement of the products of protein hydrolysis was used as a basis for development of analytical procedures. Two modifications of the original procedure were introduced as providing greater specificity for the substances to be determined.

A total of 1698 samples were analyzed, 459 by Method I, 454 by Method II, and 785 by Method III. At the stations represented by over

10 samples, average protein levels as measured by Methods II and III ranged from a maximum of 4.7 $\mu g/M^3$ to a minimum of 0.6 $\mu g/M^3$. Using data obtained only by Method III and including all stations, the maximum average concentration was 4.5 $\mu g/M^3$ minimum of 0.7 $\mu g/M^3$.

Tables showing distribution frequencies and seasonal averages are presented. It appears that 23 stations show highest values in spring, 18 in summer, 5 in fall, and 1 in winter.

With limited samples available for analysis, very little evidence was found of diurnal variation in protein levels. Data indicated that an average of 38% of the total protein may occur in the particles below approximately 5 microns in diameter. No pronounced differences were found in protein values at different elevations at the same location. No correlation could be found between the amount of acetone-soluble organic materials and the protein content of samples from several cities.

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Anchorage, Alaska	Artic Health Research Center
Atlanta, Georgia	Fulton County Health Department
Berkeley, California	State Health Department
Charleston, West Virginia	State Health Department
Chicago, Illinois	Department of Air Pollution Control
Cincinnati, Ohio	Department of Air Pollution Control
Denver, Colorado	City Building Department, Air Pollution Inspection
Detroit, Michigan	Air Pollution Control Bureau
Fort Worth, Texas	Public Health & Welfare Department
Houston, Texas	City Health Department
Kansas City, Missouri	City Health Department
Los Angeles, California	Los Angeles Air Pollution Control District
Louisville, Kentucky	Air Pollution Control District of Jefferson County

Minneapolis, Minnesota	State Department of Health
New Orleans, Louisiana	State Department of Health
New York, New York	Department of Air Pollution Control
Philadelphia, Pennsylvania	City Health Department
Portland, Oregon	State Air Pollution Authority
Salt Lake City, Utah	City Board of Health
San Jose, California	City Health Department
Tampa, Florida	Department of Public Works
Washington, D. C.	Department of Public Health

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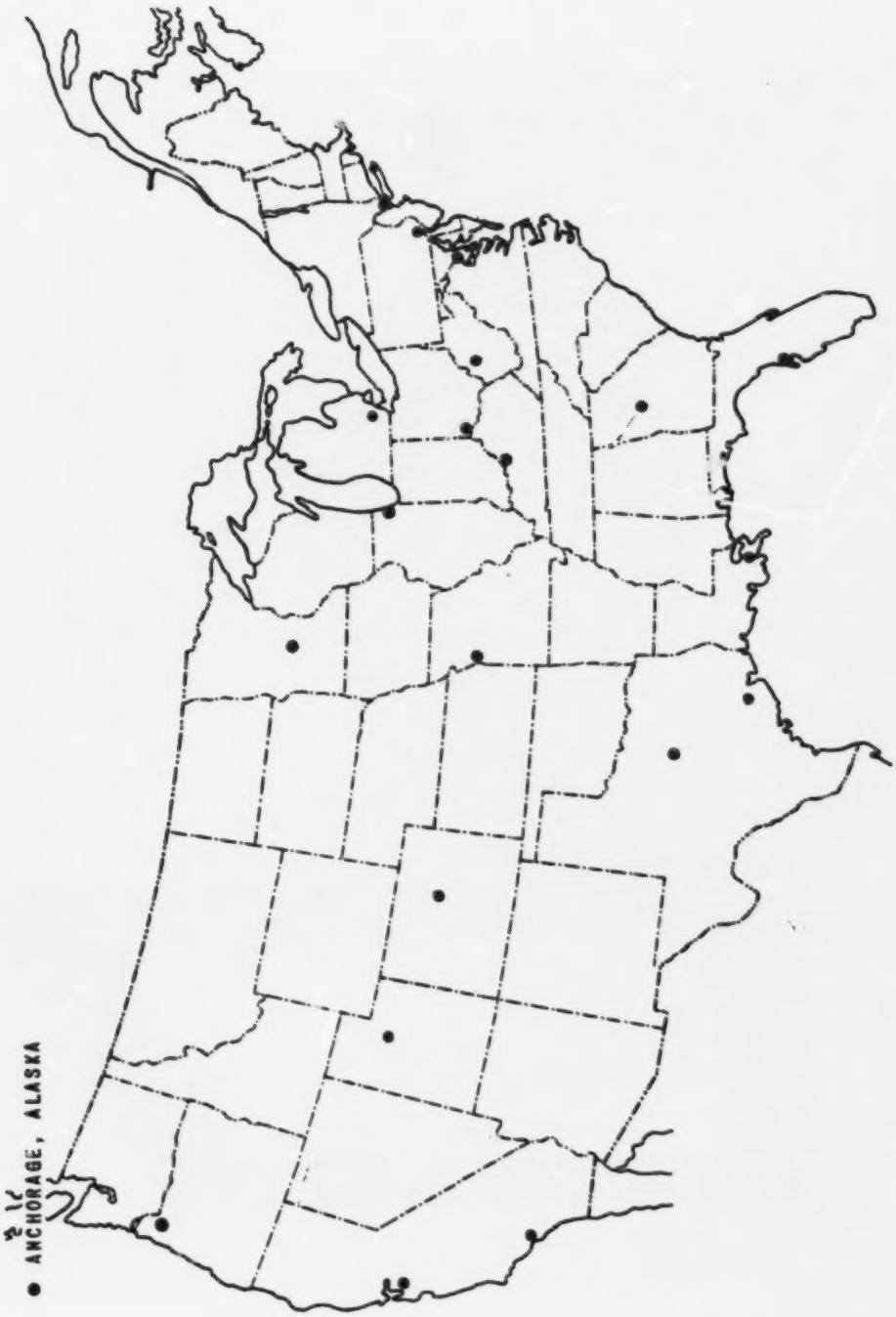

Figure 1 NATIONAL AIR SAMPLING NETWORK FOR PROTEIN STUDY, 1953-1956

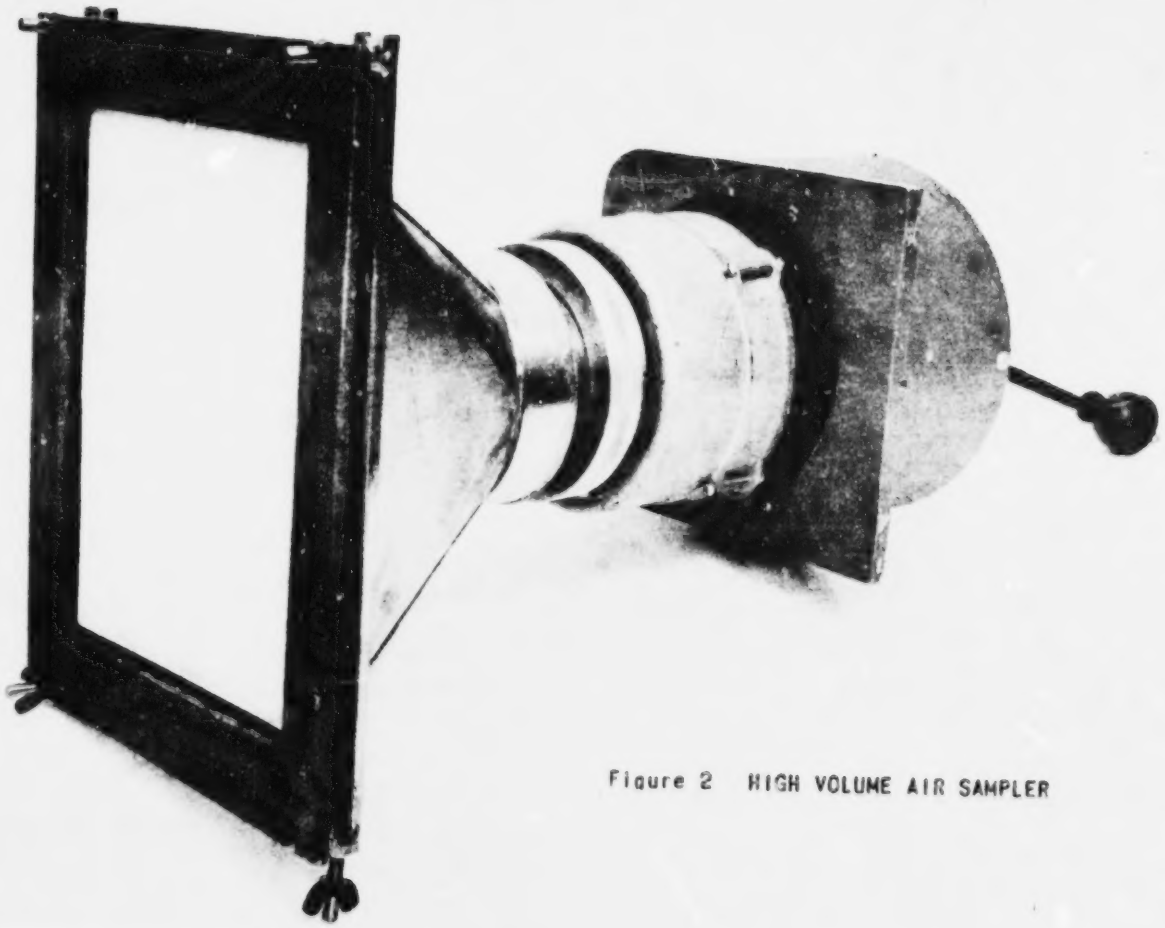

Figure 2 HIGH VOLUME AIR SAMPLER

Table 1. SAMPLING STATIONS

Community	Sampler Location		Type of Area	
	Ht., ft.	Conditions	Immediate	2-Mile radius
ANCHORAGE, ALASKA				
A - City Fire Hall	15	1,2,3		2,3
B - Rogers Park	2	2,3	3	3
C - East "K" St.	4	2,3	3	3
ATLANTA, GEORGIA				
A - Co. Health Dept.	50	1,3	1,2	1,2
B - Airport	35	1,2,3,4	1,3	1,3
C - Fire Station	15	1,3,5	3	3
D - County Farm	9	4,5	4	4
E - City Hall	200	1,3	1,2	1,2
CHARLESTON, WEST VIRGINIA				
A - State Office Bldg.	120	1,3	2,3	2,3
B - Airport	35	1,3,4,5	4	3,4
C - Oak Hill	12	5	3,4	3,4
D - Parking Bldg.	60	1	1,2,3	1,2,3
CHICAGO, ILLINOIS				
A - Water Tower	20	1	2	1,2,3
B - City Shops	46	1,3	2	1,2,3
C - 7300 Pratt Blvd.	40	1,2,3	3	3
D - Filtration Plant	35	1,3,4	1	1,3
CINCINNATI, OHIO				
A - Lincoln Park	80	1,3	1,2,3	1,2,3
B - Abbe Observatory	30	1,3,5	3	1,3
C - Winton Woods	25	2,3,4,5	4	4
D - S.E.C. Bldg.	80	1,3,4,5	1,3	1,3
E - Murray Road	2	1,3,4	1,2	1,2,3
F - West Fork Dam	2	3,4,5	4	4
G - Post Office	90	1	1,2	1,2
H - Post Office Annex	70	1	1,2	1,2
DENVER, COLORADO				
A - School Ad. Bldg.	55	1	2,3	2,3
B - Moffat Plant	50	1,3,4	3	3
C - Lake Jr. High	50	1,3,4	3	3
DETROIT, MICHIGAN				
A - Majestic Bldg.	150	1,3	2	1,2
B - Woodward & Mich.	8	1,3	2	1,2
C - Ypsilanti	10	1,3	3	3

Table 1. SAMPLING STATIONS (Continued)

Community	Sampler Location		Type of Area	
	Ht., ft.	Conditions	Immediate	2-Mile radius
FORT WORTH, TEXAS				
A - City Hall	60	1	2	2
C - Lake Worth	15	1,2,3,4	3	3
HOUSTON, TEXAS				
A - Police Bldg.	85	1	1,2	1,2
A - " "	50	1	1,2	1,2
A - " "	18	1	1,2	1,2
C - Bellaire, P. O.	20	1,2,3,4	2,3	2,3
KANSAS CITY, MISSOURI				
A - Federal Bldg.	200	1	2	1,2,3
B - 1325 Oak	15	1	1,2,3	1,2,3
C - 309 E. 68th St.	3	1,3	3	3
LOS ANGELES, CALIFORNIA				
A - Vernon Area	15	1	1	1
D - Calif. Inst. of Tech.	55	1,3	3	3
LOUISVILLE, KENTUCKY				
A - 37th and Broadway	15	1,3	3	3
B - 5600 S. 3rd St.	20	1,3	3	3
C - Iriquois Park	12	3,5	4	4
MINNEAPOLIS, MINNESOTA				
A - Board of Health	64	1,3	1,2	1,2
C - Tonka Bay	7	3,5	3	3
D - Edina	5	3,5	3,4	3,4
NEW ORLEANS, LOUISIANA				
A - City Hall Annex	80	1	2,3	1,2,3
B - S.R.R. Lab.	57	3,4	3	3
NEW YORK, NEW YORK				
B - Greenpoint	25	1	1,2,3	1,2,3
C - Central Park	75	1,3,4,5	3	3
PHILADELPHIA, PENNSYLVANIA				
A - City Hall Annex	236	1	2	1,2,3
B - Lombard Lab.	20	1	1,2,3	1,2,3
C - Greenhills Manor	50	1,3	3	3

Table 1. SAMPLING STATIONS (Continued)

Community	Sampler Location		Type of Area	
	Ht., ft.	Conditions	Immediate	2-Mile radius
PORTLAND, OREGON				
A - State Office Bldg.	125	1	2	2
B - Guilds Lake	45	1,2	1	1
C - Rigler School	50	1,3	3	3
D - Rocky Butte	25	3,4	1,3	1,3
E - Fire Station #16	30	1,3	1	1
F - Fire Station #30	45	1,3	1,3	1,3
SALT LAKE CITY, UTAH				
A - A.P. Station	16	1,2	1,2	1,2
B - Police Station	60	1	1,2	1,2,3
C - DOH Station	16	1,3,4	3	2,3
D - Rifle Range	20	2,3,4,5	4	4
SAN FRANCISCO, CALIFORNIA				
A - Berkeley	12	1	2	2
C - San Jose	14	1,3	3	3
TAMPA, FLORIDA				
A - City Hall	50	1	1,2	1,2,3
C - Airport	25	1,3,4	3,4	3,4
WASHINGTON, D. C.				
A - HEW Bldg.	70	1,3	2,3	2,3

CODE FOR SAMPLING SITE DESCRIPTION:

Surrounding surface conditions:

1. Paved surface
2. Unpaved surface
3. Grass area
4. Fields or open area
5. Wooded area

Type of immediate surrounding area:

1. Industrial
2. Commercial
3. Residential
4. Rural

Predominating activities in 2 mile radius:

1. Industrial
2. Commercial
3. Residential
4. Rural

Table 2. QUARTERLY DISTRIBUTION OF SAMPLES ANALYZED BY METHODS II AND III

Station	Method II				Method III			
	Winter	Spring	Summer	Fall	Winter	Spring	Summer	Fall
Anchorage A	-	6	-	-	-	1	6	6
Anchorage B	-	3	1	-	-	-	5	4
Anchorage C	1	4	-	-	-	-	-	-
Atlanta A	2	8	-	-	-	-	12	-
Atlanta B	3	5	-	-	-	-	-	-
Atlanta C	2	-	-	-	-	-	-	-
Atlanta D	1	8	-	-	-	-	12	-
Charleston A	2	11	1	-	-	1	11	2
Charleston B	-	8	1	-	-	-	9	7
Charleston D	-	-	-	-	-	-	-	2
Chicago A	-	6	-	-	-	1	11	-
Chicago B	-	6	1	-	-	-	12	14
Chicago C	-	8	1	-	-	-	23	6
Cincinnati A	2	22	-	-	-	-	22	-
Cincinnati B	3	15	2	-	-	-	11	-
Cincinnati C	3	1	-	-	-	-	-	-
Cincinnati D	7	13	1	-	-	-	13	12
Cincinnati E	1	13	-	-	-	-	2	11
Cincinnati F	-	9	2	-	-	-	9	-
Denver A	-	4	-	-	-	-	9	7
Denver B	-	-	-	-	-	-	9	12
Denver C	-	4	-	-	-	-	4	-
Detroit A	2	6	-	-	-	-	3	-
Detroit B	-	1	-	-	-	-	-	-
Detroit C	4	3	-	-	-	-	-	-
Fort Worth A	2	10	-	-	-	1	14	13
Fort Worth C	1	-	1	7	-	-	9	12
Houston A -85'	3	14	-	-	-	-	18	16
Houston A -50'	1	3	-	-	-	-	2	0
Houston A -18'	-	-	-	-	-	-	2	4
Houston C	-	2	-	-	-	-	9	8
Kansas City B	1	5	-	-	-	-	5	4
Kansas City C	2	4	-	-	-	-	5	4

Table 2. QUARTERLY DISTRIBUTION OF SAMPLES ANALYZED BY METHODS II AND III (Continued)

Station	Method II				Method III			
	Winter	Spring	Summer	Fall	Winter	Spring	Summer	Fall
Los Angeles A	2	10	-	-	-	-	2	-
Los Angeles B	-	3	-	-	-	-	-	-
Los Angeles C	2	-	-	-	-	-	-	-
Los Angeles D	2	9	-	-	-	-	9	3
Louisville A	1	6	2	-	-	-	7	5
Louisville B	-	-	-	-	-	-	8	5
Louisville C	-	5	-	-	-	-	-	-
Minneapolis A	3	12	-	-	-	-	11	-
Minneapolis B	-	-	-	-	-	-	4	-
Minneapolis C	1	12	1	-	-	-	6	-
New Orleans A	-	6	-	-	-	-	9	9
New Orleans B	-	6	-	-	-	-	12	11
New York B	2	7	-	-	-	-	9	10
New York C	3	6	-	-	-	1	10	12
New York D	1	-	-	-	-	-	-	-
Philadelphia A	2	2	-	-	-	3	16	48
Philadelphia B	-	-	-	-	-	-	-	6
Philadelphia C	3	1	-	-	-	4	8	9
Portland A	8	3	-	-	-	2	6	10
Portland B	2	3	-	-	-	2	7	10
Portland C	1	-	-	-	-	-	-	-
Portland D	1	2	-	-	-	-	3	10
Portland E	-	-	-	-	-	-	-	10
Portland F	-	-	-	-	-	-	-	10
Salt Lake City B	-	4	3	-	-	-	9	-
Salt Lake City C	1	-	-	-	-	-	-	-
Salt Iake City D	-	3	3	-	-	-	6	-
San Francisco A	1	7	-	-	-	-	7	-
San Francisco C	1	6	-	-	-	-	7	-
Tampa A	1	9	-	-	-	-	12	11
Tampa C	3	7	-	-	-	1	9	9
Washington A	2	10	-	-	-	-	10	2
	86	341	20	7	0	17	434	334
%	18.9	75.1	4.4	1.5	0	2.2	55.3	42.5

Table 3. COMPARISON OF METHODS II AND III WHERE AVAILABLE FOR SAME QUARTER OF YEAR

Station	Method II				Method III		
	Qtr.	No.	Range	Average	No.	Range	Average
Anchorage A	(2)	6	1.5-4.7	2.8	1	2.1	2.1
Anchorage B	(3)	1	3.0	3.0	5	0.6-1.9	1.5
Charleston A	(3)	1	3.3	3.3	11	1.3-4.7	2.5
Charleston B	(3)	1	1.1	1.1	9	0.7-3.2	1.6
Chicago A	(2)	6	0.8-3.6	2.2	1	1.5	1.5
Chicago B	(3)	1	2.6	2.6	12	1.4-5.5	3.2
Chicago C	(3)	1	2.5	2.5	23	0.3-3.4	1.4
Cincinnati B	(3)	2	1.9-2.6	2.2	11	0.9-3.2	1.8
Cincinnati D	(3)	1	1.8	1.8	13	0.8-3.4	1.7
Cincinnati F	(3)	2	1.2	1.2	9	0.2-1.1	0.7
Fort Worth C	(3)	1	1.1	1.1	9	0.2-2.6	1.4
Fort Worth A	(4)	7	0.5-2.7	1.5	12	0.6-4.3	1.6
Louisville A	(3)	2	1.7-2.4	2.0	7	0.8-2.5	1.9
New York C	(2)	6	1.2-2.1	1.8	1	2.3	2.3
Philadelphia A	(2)	2	1.2-1.8	1.5	3	1.1-1.3	1.2
Philadelphia C	(2)	1	3.4	3.4	4	0.5-1.6	1.0
Portland A	(2)	3	0.6-1.7	1.0	2	1.1-1.7	1.4
Portland B	(2)	3	0.7-1.1	0.9	2	0.7-1.7	1.2
Salt Lake City B	(3)	3	1.7-3.3	2.4	9	0.9-2.3	1.4
Salt Lake City D	(3)	3	1.0-1.5	1.3	6	0.4-1.1	0.8
Tampa C	(2)	7	0.2-0.6	0.4	1	0.3	0.3
		60	0.2-4.7	1.9	151	0.2-5.5	1.5
		Range		0.4-3.4			0.3-3.2

Table 4. RANGE BY STATIONS - PROTEIN $\mu g/M^3$
METHODS II AND III ONLY

Station	Number of Samples	Minimum	Maximum	Average
Anchorage A	19	0.7	3.7	2.0
Anchorage B	13	0.6	6.6	2.3
Anchorage C	5	0.9	13.7	6.5
Atlanta A	22	0.8	3.2	1.8
Atlanta B	8	0.5	3.1	1.4
Atlanta C	2	0.7	0.9	0.8
Atlanta D	21	0.7	4.8	1.5
Charleston A	28	0.7	6.7	2.7
Charleston B	25	0.4	3.6	1.3
Chicago A	18	0.6	3.7	2.0
Chicago B	33	1.4	6.5	3.3
Chicago C	38	0.3	3.4	1.6
Cincinnati A	46	0.8	6.4	2.0
Cincinnati B	31	0.5	10.5	2.0
Cincinnati C	4	0.4	1.9	1.0
Cincinnati D	46	0.0	3.4	1.2
Cincinnati E	27	0.6	10.9	2.1
Cincinnati F	20	0.2	2.1	1.0
Denver A	20	1.0	3.2	1.8
Denver B	21	0.5	2.0	1.0
Denver C	8	0.9	2.8	2.0
Detroit A	11	1.2	12.1	3.5
Detroit C	7	0.4	2.3	1.1
Fort Worth A	40	0.5	19.0	1.9
Fort Worth C	30	0.2	4.3	1.5
Houston A-85'	51	0.2	6.9	1.5
Houston A-50'	5	0.4	1.4	0.8
Houston A-18'	6	0.8	3.7	1.9
Houston C	19	0.8	3.3	1.4
Kansas City B	15	1.1	4.0	2.0
Kansas City C	15	1.5	3.9	2.6
Los Angeles A	14	2.5	10.2	4.7
Los Angeles B	3	1.4	3.2	2.1
Los Angeles C	2	0.7	1.0	0.9
Los Angeles D	23	0.9	6.3	3.1

Table 4. RANGE BY STATIONS - PROTEIN $\mu g/M^3$
METHODS II AND III ONLY (Continued)

Station	Number of Samples	Minimum	Maximum	Average
Louisville A	21	0.5	3.9	2.0
Louisville B	13	0.7	2.6	1.7
Louisville C	5	0.9	11.0	3.4
Minneapolis A	26	0.9	5.5	2.4
Minneapolis B	4	0.9	4.4	2.8
Minneapolis C	20	0.0	4.2	1.4
New Orleans A	24	0.7	2.9	1.4
New Orleans B	29	0.6	2.9	1.3
New York B	28	1.1	10.1	3.8
New York C	32	0.3	3.6	1.9
Philadelphia A	71	0.6	4.7	1.9
Philadelphia B	6	3.7	5.6	4.5
Philadelphia C	25	0.4	3.4	1.4
Portland A	29	0.1	5.6	1.9
Portland B	24	0.5	3.1	1.5
Portland D	16	0.4	2.4	1.2
Portland E	10	1.0	3.4	2.3
Portland F	10	0.8	4.8	2.4
Salt Lake City B	16	0.6	3.3	1.5
Salt Lake City D	12	0.4	1.5	1.0
San Francisco A	15	0.3	3.1	1.0
San Francisco C	14	0.4	3.4	1.3
Tampa A	33	0.3	4.1	1.3
Tampa C	30	0.2	1.7	0.6
Washington A	24	0.5	10.2	2.1

Table 5. RANGE BY STATIONS - PROTEIN $\mu g/M^3$
METHOD III ONLY

Station	Number of Samples	Minimum	Maximum	Average
Anchorage A	13	0.7	2.2	1.6
Anchorage B	9	0.6	3.3	1.7
Atlanta A	12	1.2	3.2	1.8
Atlanta D	12	0.9	1.8	1.3
Charleston A	14	1.3	4.7	2.5
Charleston B	16	0.4	3.2	1.2
Charleston D	2	1.8	1.8	1.8
Chicago A	12	0.6	3.7	1.9
Chicago B	26	1.4	5.8	3.3
Chicago C	29	0.5	3.4	1.5
Cincinnati A	22	1.0	3.9	2.1
Cincinnati B	11	0.9	3.2	1.8
Cincinnati D	25	0.3	3.4	1.3
Cincinnati E	13	0.5	1.8	1.1
Cincinnati F	9	0.2	1.1	0.7
Denver A	16	1.0	3.2	1.7
Denver B	21	0.4	2.0	1.0
Denver C	4	0.9	2.5	1.8
Detroit A	3	3.1	3.7	3.3
Fort Worth A	28	0.5	3.4	1.6
Fort Worth C	21	0.2	4.3	1.6
Houston A-85'	34	0.2	4.2	1.6
Houston A-50'	2	0.4	1.4	0.9
Houston A-18'	6	0.8	3.7	1.9
Houston C	17	0.8	3.3	1.6
Kansas City B	9	1.1	4.0	2.3
Kansas City C	9	1.5	3.9	2.5
Los Angeles A	2	2.5	3.0	2.7
Los Angeles D	12	1.9	6.3	3.3

Table 5. RANGE BY STATIONS - PROTEIN $\mu g/M^3$
METHOD III ONLY (Continued)

Station	Number of Samples	Minimum	Maximum	Average
Louisville A	12	0.5	3.1	1.9
Louisville B	13	0.7	2.6	1.7
Minneapolis A	11	1.1	5.5	2.8
Minneapolis B	4	0.9	4.4	2.8
Minneapolis C	6	0.0	2.2	1.1
New Orleans A	18	0.7	2.9	1.5
New Orleans B	23	0.6	2.9	1.3
New York B	19	1.1	6.4	3.3
New York C	23	0.7	4.3	2.2
Philadelphia A	67	0.8	4.6	2.0
Philadelphia B	6	3.7	5.6	4.5
Philadelphia C	21	0.4	2.7	1.4
Portland A	18	0.4	4.3	2.0
Portland B	19	0.7	3.1	1.6
Portland D	13	0.7	2.4	1.3
Portland E	10	1.0	3.4	2.3
Portland F	10	0.8	4.8	2.4
Salt Lake City B	9	1.1	2.3	1.4
Salt Lake City D	6	0.4	1.1	0.8
San Francisco A	7	0.3	3.1	1.3
San Francisco B	7	0.4	1.8	0.9
Tampa A	23	0.3	4.1	1.5
Tampa C	19	0.2	1.7	0.7
Washington A	12	0.9	2.2	1.6

Table 6. STATIONS RANKED BY AVERAGE PROTEIN LEVELS ($\mu g/M^3$) OVER 10 SAMPLES METHODS II AND III

Station	Number of Samples	Average	Maximum
Los Angeles A	14	4.7	10.2
New York B	28	3.8	10.1
Detroit A	11	3.5	12.1
Chicago B	33	3.3	6.5
Los Angeles D	23	3.1	6.3
Charleston A	28	2.7	6.7
Kansas City C	15	2.6	3.9
Minneapolis A	26	2.4	5.5
Anchorage B	13	2.3	6.6
Washington A	24	2.1	10.2
Cincinnati E	27	2.1	10.9
Anchorage A	19	2.0	3.7
Chicago A	18	2.0	3.7
Cincinnati A	46	2.0	6.4
Cincinnati B	31	2.0	10.5
Kansas City B	15	2.0	4.0
Louisville A	21	2.0	3.9
Fort Worth A	40	1.9	19.0
New York C	32	1.9	3.6
Philadelphia A	71	1.9	4.7
Portland A	29	1.9	5.6
Atlanta A	22	1.8	3.2
Denver A	20	1.8	3.2
Louisville B	13	1.7	2.6
Chicago C	38	1.6	3.4
Atlanta D	21	1.5	4.8
Fort Worth C	30	1.5	4.3
Houston A-85'	51	1.5	6.9
Portland B	24	1.5	3.1
Salt Lake City B	16	1.5	3.3
Houston C	19	1.4	3.3
Minneapolis C	20	1.4	4.2
New Orleans A	24	1.4	2.9
Philadelphia C	25	1.4	3.4
Charleston B	25	1.3	3.6

Table 6. STATIONS RANKED BY AVERAGE PROTEIN LEVELS ($\mu g/M^3$) OVER 10 SAMPLES METHODS II AND III (Continued)

Station	Number of Samples	Average	Maximum
New Orleans B	29	1.3	2.9
San Francisco C	14	1.3	3.4
Tampa A	33	1.3	4.1
Cincinnati D	46	1.2	3.4
Portland D	16	1.2	2.4
Cincinnati F	20	1.0	2.1
Denver B	21	1.0	2.0
Salt Lake City D	12	1.0	1.5
San Francisco A	15	1.0	3.1
Tampa C	30	0.6	1.7

Table 7. RANKED BY STATION AVERAGE, PROTEIN LEVELS ($\mu g/M^3$) METHOD III ONLY

Station	Number of Samples	Minimum	Maximum	Average
Philadelphia B	6	3.7	5.6	4.5
Chicago B	26	1.4	5.8	3.3
Detroit A	3	3.1	3.7	3.3
Los Angeles D	12	1.9	6.3	3.3
New York B	19	1.1	6.4	3.3
Minneapolis A	11	1.1	5.5	2.8
Minneapolis B	4	0.9	4.4	2.8
Los Angeles A	2	2.5	3.0	2.7
Charleston A	14	1.3	4.7	2.5
Kansas City C	9	1.5	3.9	2.5
Portland F	10	0.8	4.8	2.4
Kansas City B	9	1.1	4.0	2.3
Portland E	10	1.0	3.4	2.3
New York C	23	0.7	4.3	2.2
Cincinnati A	22	1.0	3.9	2.1
Philadelphia A	67	0.8	4.6	2.0
Portland A	18	0.4	4.3	2.0
Chicago A	12	0.6	3.7	1.9
Houston A-18'	6	0.8	3.7	1.9
Louisville A	12	0.5	3.1	1.9
Atlanta A	12	1.2	3.2	1.8
Charleston D	2	1.8	1.8	1.8
Cincinnati B	11	0.9	3.2	1.8
Denver C	4	0.9	2.5	1.8
Anchorage B	9	0.6	3.3	1.7
Denver A	16	1.0	3.2	1.7
Louisville B	13	0.7	2.6	1.7
Anchorage A	13	0.7	2.2	1.6
Fort Worth A	28	0.5	3.4	1.6
Fort Worth C	21	0.2	4.3	1.6

Table 7. RANKED BY STATION AVERAGE, PROTEIN LEVELS ($\mu g/M^3$) METHOD III ONLY (Continued)

Station	Number of Samples	Minimum	Maximum	Average
Houston A-85'	34	0.2	4.2	1.6
Houston C	17	0.8	3.3	1.6
Portland B	19	0.7	3.1	1.6
Washington A	12	0.9	2.2	1.6
Chicago C	29	0.5	3.4	1.5
New Orleans A	18	0.7	2.9	1.5
Tampa A	23	0.3	4.1	1.5
Philadelphia C	21	0.4	2.7	1.4
Salt Lake City B	9	1.1	2.3	1.4
Atlanta D	12	0.9	1.8	1.3
Cincinnati D	25	0.3	3.4	1.3
New Orleans B	23	0.6	2.9	1.3
Portland D	13	0.7	2.4	1.3
San Francisco A	7	0.3	3.1	1.3
Charleston B	16	0.4	3.2	1.2
Cincinnati E	13	0.5	1.8	1.1
Minneapolis C	6	0.0	2.2	1.1
Denver B	21	0.4	2.0	1.0
Houston A-50'	2	0.4	1.4	0.9
San Francisco C	7	0.4	1.8	0.9
Salt Lake City D	6	0.4	1.1	0.8
Cincinnati F	9	0.2	1.1	0.7
Tampa C	19	0.2	1.7	0.7

Table 8. FREQUENCIES OF LOADINGS BY STATIONS, $\mu g/M^3$ PROTEIN, IN PERCENTAGE OF DAYS METHODS II AND III

Station	0.-0.5	0.5-1.0	1.0-1.5	1.5-2.0	2.0-3.0	3.0-4.0	4.0-5.0	5.0-10.0	Over 10.0
Los Angeles A	-	-	-	-	14	29	22	36	7
New York B	-	-	7	7	25	32	11	10	7
Detroit A	-	-	9	9	36	36	-	-	9
Chicago B	-	-	6	12	27	30	12	12	-
Los Angeles D	-	4	-	4	39	35	13	4	-
Charleston A	-	10	11	14	36	7	7	11	-
Kansas City C	-	-	-	27	47	20	7	-	-
Minneapolis A	-	8	19	19	15	27	8	4	-
Anchorage B	-	15	-	39	15	23	-	8	-
Washington A	-	17	33	17	25	-	-	4	4
Cincinnati E	-	26	30	19	11	-	-	11	4
Anchorage A	-	10	16	26	37	5	5	-	-
Chicago A	-	22	17	17	17	28	-	-	-
Cincinnati A	-	9	17	26	26	15	2	2	-
Cincinnati B	-	16	39	23	13	3	-	3	3
Kansas City B	-	-	33	20	27	13	7	-	-
Louisville A	-	10	14	19	43	14	-	-	-
Fort Worth A	-	20	30	18	22	5	-	-	2
New York C	3	6	25	19	37	6	3	-	-
Philadelphia A	-	7	23	34	21	11	4	-	-
Portland A	10	17	14	24	14	14	4	3	-
Atlanta A	-	5	32	36	18	9	-	-	-
Denver A	-	-	30	35	20	10	-	-	-
Louisville B	-	8	23	46	23	-	-	-	-
Chicago C	3	21	29	18	24	5	-	-	-
Atlanta D	-	5	33	38	19	10	-	-	-
Fort Worth C	3	20	37	13	23	-	3	-	-
Houston A	6	35	14	16	22	4	2	2	-
Portland B	-	33	17	21	21	8	-	-	-
Salt Lake City B	-	12	44	13	19	6	-	-	-

Table 8. FREQUENCIES OF LOADINGS BY STATIONS, $\mu g/M^3$ PROTEIN, IN PERCENTAGE OF DAYS METHODS II AND III (Continued)

Station	0.- 0.5	0.5- 1.0	1.0- 1.5	1.5- 2.0	2.0- 3.0	3.0- 4.0	4.0- 5.0	5.0- 10.0	Over 10.0
Houston C	-	26	37	16	16	5	-	-	-
Minneapolis C	15	5	45	15	5	5	5	-	-
New Orleans A	-	29	33	17	21	-	-	-	-
Philadelphia C	8	16	24	32	16	4	-	-	-
Charleston B	4	36	28	16	8	8	-	-	-
New Orleans B	-	38	35	20	7	-	-	-	-
San Francisco C	7	36	28	7	14	7	-	-	-
Tampa A	3	39	30	12	6	6	3	-	-
Cincinnati D	15	17	35	20	11	2	-	-	-
Portland D	6	37	31	-	25	-	-	-	-
Cincinnati F	10	40	35	5	10	-	-	-	-
Denver B	5	43	43	5	5	-	-	-	-
Salt Lake City D	17	25	42	16	-	-	-	-	-
San Francisco A	20	40	20	13	-	7	-	-	-
Tampa C	47	37	10	3	-	-	-	-	-

Table 9. FREQUENCIES OF LOADINGS BY STATIONS, $\mu g/M^3$ PROTEIN, IN PERCENTAGE OF DAYS METHOD III ONLY

Station	0.-0.5	0.5-1.0	1.0-1.5	1.5-2.0	2.0-3.0	3.0-4.0	4.0-5.0	5.0-6.5
Chicago B	-	-	8	8	27	35	15	8
Los Angeles D	-	-	-	8	33	33	17	8
New York B	-	-	11	11	26	32	5	16
Minneapolis A	-	-	9	27	18	36	-	9
Charleston A	-	-	7	14	57	14	7	-
Kansas City C	-	-	-	22	55	22	-	-
Portland F	-	10	10	10	60	-	10	-
Kansas City B	-	-	33	11	22	22	11	-
Portland E	-	-	20	10	50	20	-	-
New York C	-	4	22	17	43	9	4	-
Cincinnati A	-	-	18	27	36	18	-	-
Philadelphia A	-	4	23	34	23	11	4	-
Portland A	6	11	11	28	22	17	6	-
Chicago A	-	25	17	17	17	25	-	-
Louisville A	-	17	8	8	58	8	-	-
Atlanta A	-	-	25	50	17	8	-	-
Cincinnati B	-	9	27	36	18	9	-	-
Anchorage B	-	22	-	56	11	11	-	-
Denver A	-	-	38	31	25	6	-	-
Louisville B	-	8	23	46	23	-	-	-
Anchorage A	-	15	23	23	39	-	-	-
Fort Worth A	-	18	37	19	19	7	-	-
Fort Worth C	5	19	38	10	24	-	5	-
Houston A	6	29	12	18	27	6	3	-
Houston C	-	18	41	18	17	6	-	-
Portland B	-	26	16	16	21	11	-	-
Washington A	-	8	42	25	25	-	-	-
Chicago C	3	21	38	14	17	7	-	-
New Orleans A	-	33	28	17	22	-	-	-
Tampa A	4	26	30	17	9	9	4	-

Table 9. FREQUENCIES OF LOADINGS BY STATIONS, $\mu g/M^3$ PROTEIN, IN PERCENTAGE OF DAYS METHOD III ONLY (Continued)

Station	0.- 0.5	0.5- 1.0	1.0- 1.5	1.5- 2.0	2.0- 3.0	3.0- 4.0	4.0- 5.0	5.0- 6.5
Philadelphia C	5	14	24	38	19	-	-	-
Salt Lake City B	-	11	55	11	22	-	-	-
Atlanta D	-	17	50	33	-	-	-	-
Cincinnati D	12	20	28	24	12	4	-	-
New Orleans B	-	39	30	22	9	-	-	-
Portland D	-	31	38	-	31	-	-	-
San Francisco A	-	13	25	25	13	12	-	-
Charleston B	6	37	31	13	12	12	-	-
Cincinnati E	-	46	31	23	-	-	-	-
Denver B	5	43	43	5	4	-	-	-
San Francisco C	12	38	25	25	-	-	-	-
Cincinnati F	21	44	35	-	-	-	-	-
Tampa C	26	53	16	5	-	-	-	-

Table 10. QUARTERLY PROTEIN AVERAGES, $\mu g/M^3$
METHODS II AND III
Items in ( ) indicate Method I

Station	Jan.-Mar. Winter	Apr.-June Spring	July-Sept. Summer	Oct.-Dec. Fall
Anchorage A	(2.1)	2.8	1.5	1.7
Anchorage A	-	4.2	1.7	2.0
Anchorage C	(1.0)	8.1	-	(2.0)
Atlanta A	(2.9)	1.7	1.8	(1.2)
Atlanta B	(0.9)	1.8	-	(1.0)
Atlanta C	(1.0)	-	-	-
Atlanta D	0.9	1.8	1.3	-
Charleston A	1.2	3.1	2.5	2.0
Charleston B	-	1.6	1.6	0.7
Charleston C	(1.3)	-	-	(2.1)
Charleston D	-	-	-	1.8
Chicago B	-	3.5	3.1	3.3
Chicago C	-	1.8	1.5	1.6
Cincinnati A	(1.3)	2.2	2.1	(4.9)
Cincinnati B	(1.1)	2.3	1.9	(4.7)
Cincinnati C	(0.9)	-	-	(4.1)
Cincinnati D	0.5 (1.5)	1.4	1.7	0.9
Cincinnati E	(3.2) (1.9)	3.3	0.8	1.2
Cincinnati F	-	1.3	0.7	-
Denver A	-	2.0	1.5	2.0
Denver B	-	-	0.9	1.1
Detroit A	(2.2)	4.0	3.3	(3.2)
Detroit B	(6.1)	9.6	-	(5.3)
Detroit C	0.8	1.5	-	-
Fort Worth A	7.3 (1.5)	1.5	1.3	1.9
Fort Worth C	1.5	-	1.4	1.6
Houston A - 85'	1.9	1.3	1.0	2.3
Houston C	(1.3)	0.8	1.2	1.9
Houston A - 50'	-	0.7	0.9	-
Houston A - 18'	-	-	0.8	2.9
Kansas City A	(0.8)	-	-	(2.2)
Kansas City B	(3.2)	1.8	2.8	1.7
Kansas City C	4.2 (2.7)	2.2	2.2	2.8

Table 10. QUARTERLY PROTEIN AVERAGES, $\mu g/M^3$
METHODS II AND III
(Continued) Items in ( ) indicated Method I

Station	Jan.-Mar. Winter	Apr.-June Spring	July-Sept. Summer	Oct.-Dec. Fall
Los Angeles A	3.5	5.3	2.8	-
Los Angeles B	-	2.1	-	-
Los Angeles C	0.9	-	-	-
Los Angeles D	2.4	3.0	2.9	4.7(9.2)
Louisville A	1.0	2.5	1.8	2.0
Louisville B	-	-	2.0	1.3
Louisville C	-	3.4	-	-
Minneapolis A	1.2(1.9)(4.2)	2.4	2.8	(3.3)
Minneapolis B	-	-	2.8	-
Minneapolis C	(0.7)	1.4	1.5	(0.6)
New Orleans A	-	1.3	1.1	1.8
New Orleans B	-	1.2	1.1	1.6
New York B	2.5(16.4)	5.7	3.5	3.0
New York C	0.8(1.6)	1.8	2.5	1.8
Philadelphia A	0.7(16.2)	1.3	1.5	2.2
Philadelphia B	-	-	-	4.5
Philadelphia C	0.7	1.4	1.5	1.6
Portland A	1.8	1.2	1.2	2.7
Portland B	1.5	1.0	1.2	2.1
Portland C	(0.9)	-	-	-
Portland D	0.5	0.7	0.9	1.5
Portland E	-	-	-	2.3
Portland F	-	-	-	2.4
Salt Lake City A	(4.6)	-	-	(1.4)
Salt Lake City B	-	1.0	1.7	-
Salt Lake City C	(1.1)	-	-	-
Salt Lake City D	-	1.0	0.9	-
San Francisco A	(2.6)	0.8	1.3	-
San Francisco C	(1.2)	1.8	0.9	-
Tampa A	(1.2)	0.7	1.1	2.0
Tampa C	0.3	0.4	0.5	0.9
Washington A	0.7(2.5)	2.9	1.5	1.7(1.8)

Table 11. SIX-HOUR PERCENTAGES OF TOTAL DAILY PROTEIN COLLECTION

	CINCINNATI POST OFFICE			
Date, 1955	2:30PM-8:30PM	8:30PM-2:30AM	2:30AM-8:30AM	8:30AM-2:30PM
4/12-13	43.1	33.9	8.5	13.6
4/13-14	8.5	6.4	40.3	44.8
4/14-15	33.3	15.4	22.2	29.1
Av.	28.3	18.6	23.7	29.2
	3:15PM-9:15PM	9:15PM-3:15AM	3:15AM-9:15AM	9:15AM-3:15PM
4/18-19	31.2	21.6	20.8	26.4
4/19-20	28.8	25.0	24.3	22.0
4/25-26	12.9	48.4	16.1	22.6
4/26-27	33.8	7.0	35.2	24.0
4/27-28	39.2	17.4	34.8	8.7
4/28-29	29.9	26.8	26.8	16.5
Av.	29.3	24.4	26.3	20.0

	CINCINNATI POST OFFICE ANNEX			
Date, 1955	1 PM-7 PM	7 PM-1 AM	1 AM-7 AM	7 AM-1 PM
4/11-12	35.8	13.7	17.9	32.6
4/12-13	37.3	5.1	18.6	39.0
4/14-15	32.9	22.0	13.7	31.4
Av.	35.3	13.6	16.7	34.3
	10AM-4 PM	4PM-10PM	10PM-4 AM	4 AM-10AM
4/18-19	23.0	29.2	19.2	28.6
4/19-20	23.2	21.8	31.8	23.2
4/20-21	26.4	27.7	22.0	24.8
4/21-22	6.3	11.4	35.4	46.9
4/25-26	56.5	17.4	13.0	13.0
4/26-27	49.2	14.8	16.4	19.6
4/27-28	22.4	27.6	18.9	31.1
4/28-29	27.4	26.5	18.0	28.2
Av.	29.3	22.1	21.8	26.8

	ROBERT A. TAFT SANITARY ENGINEERING CENTER			
Date, 1955	12 N-6 PM	6 PM-12 M	12 M-6 AM	6 AM-12 N
3/7-8	22.7	50.0	11.4	15.9
3/8-9	26.8	12.5	42.9	17.8
Av.	24.7	31.0	27.2	16.9

Table 12. PERCENTAGE OF DAILY TOTAL PROTEIN IN SMALLER PARTICULATES

CINCINNATI POST OFFICE		CINCINNATI POST OFFICE ANNEX	
Date, 1955	Percentage	Date, 1955	Percentage
3/24-25	26.3	4/11-12	36.8
4/4-5	72.0	4/12-13	41.5
4/6-7	47.5	4/14-15	16.7
4/7-8	52.4	4/18-19	21.6
4/12-13	56.8	4/19-20	31.2
4/13-14	61.5	4/20-21	50.0
4/14-15	25.0	4/21-22	29.4
4/18-19	29.3	4/25-26	12.5
4/19-20	31.8	4/26-27	15.4
4/25-26	11.1	4/27-28	52.1
4/26-27	17.4	4/28-29	39.9
4/27-28	29.2		
4/28-29	31.5		

SANITARY ENGINEERING CENTER	
3/14-15	58.8
3/24-25	53.4
3/28-29	62.5
3/30-31	66.7
4/4-5	12.5
4/5-6	42.2

Table 13. THE INFLUENCE OF ELEVATION ON PROTEIN LEVELS

Sampling Location	Elevation Ft.	Number of Samples	Method Used	Protein - µg/CuM Ave.	Range
Houston A	18	6	III	1.9	0.8-3.7
	85	6	III	2.0	0.6-3.8
Houston A	50	5	II & III	0.8	0.4-1.4
	85	5	II & III	0.9	0.5-2.1
Detroit A	8	15	I	6.0	1.1-12.8
	150	15	I	3.1	1.0-6.7
Philadelphia A	20	6	III	4.5	3.7-4.9
B	240	6	III	3.0	1.8-4.1

Table 14. RELATIONSHIP BETWEEN (ORGANICS) AND PROTEIN

LOUISVILLE A

Sample No.	Protein	Acetone Soluble (Organics)	Acetone Soluble (Organics) / Protein
1176	1.0	23.5	23.5
1180	1.3	17.0	13.1
1178	2.8	21.0	7.5
1182	1.9	21.0	11.1
1183	1.9	15.0	7.9
1185	3.1	19.0	6.1
1186	3.9	15.0	3.8
1188	2.4	8.0	3.3
1192	1.7	12.0	7.1
1190	2.0	4.4	2.2
1196	2.0	16.0	8.0
1198	2.1	13.9	6.6
1200	1.5	12.1	8.1
1799	0.8	8.7	10.9
1797	2.5	31.0	12.4
1795	2.0	20.7	10.3
1793	2.0	29.8	14.9
1791	1.4	68.5	49.0
1785	0.5	23.3	46.7
1781	3.1	36.3	11.7
1783	2.9	60.0	20.7

Table 15. RELATIONSHIP BETWEEN (ORGANICS) AND PROTEIN

ATLANTA A

Sample No.	Protein	Acetone Soluble (Organics)	Acetone Soluble (Organics) / Protein
1008	2.1	10.9	5.2
1011	1.7	13.9	8.2
1014	3.2	18.5	5.8
1017	1.1	13.1	11.9
1021	0.8	7.3	9.1
1023	1.4	21.1	15.1
1551	1.0	15.9	15.9
1559	1.3	19.1	14.7
1557	2.9	23.5	8.1
1561	1.8	20.4	11.3
1563	3.2	28.8	9.0
1565	1.9	20.3	10.7
1567	1.7	12.2	7.2
1569	1.4	12.7	9.1
1571	2.2	18.4	8.4
1574	1.9	15.1	8.0
2051	1.5	40.6	22.1
2054	1.2	15.5	12.9
2056	1.4	23.9	17.0
2060	1.9	25.0	13.2
2058	2.0	29.8	14.9
2064	1.8	7.4	4.1

Table 16. RELATIONSHIP BETWEEN (ORGANICS) AND PROTEIN
LOS ANGELES D

Sample No.	Protein	Acetone Soluble (Organics)	Acetone Soluble (Organics) / Protein
97	2.0	61.0	30.5
98	2.1	50.0	23.8
99	2.5	74.0	29.6
1227	3.0	56.0	18.6
100	0.9	30.0	33.3
1226	4.4	69.0	15.7
1228	2.6	52.0	20.0
1230	3.9	37.0	9.5
1231	3.5	38.0	10.9
1229	3.9	53.0	13.6
1240	2.3	39.5	17.2
1232	3.3	65.6	19.9
1233	2.1	42.6	20.3
1234	2.6	42.5	16.3
1237	3.3	56.6	17.1
1238	3.2	36.0	11.2
1239	2.8	30.9	11.0
1241	1.9	35.5	18.6
1244	4.5	109.3	24.2
1246	3.2	89.1	27.8
1247	4.6	142.9	31.0
1248	6.3	137.5	21.8

Table 17. RELATIONSHIP BETWEEN (ORGANICS) AND PROTEIN

CHICAGO B

Sample No.	Protein	Acetone Soluble (Organics)	Acetone Soluble (Organics) / Protein
1027	2.0	40.0	20.0
1032	5.3	68.0	12.8
1034	1.5	28.0	18.2
1030	1.7	37.0	21.8
1044	3.8	39.0	10.3
1042	6.5	31.0	4.8
1469	5.5	66.0	12.0
1471	2.8	45.9	16.4
1461	3.2	18.3	5.7
2007	4.7	60.0	12.8
1473	4.9	56.1	11.5
2013	3.2	22.0	6.9
2015	2.3	34.3	14.9
2019	1.9	33.0	17.4
1452	1.4	17.9	12.8
2005	4.0	77.6	19.4
2027	1.6	19.5	12.2
2035	2.8	44.5	15.8
2033	2.8	55.1	19.7
2039	3.2	26.4	8.2
2038	2.9	37.3	12.9
2036	3.6	140.9	39.0
2030	2.2	37.9	17.2
2043	4.7	126.9	27.0
2048	2.2	59.6	27.0
2947	3.6	119.0	33.0
2949	1.4	65.6	46.8
2040	3.7	56.7	15.3
2941	3.7	53.4	14.4
2935	3.2	54.4	17.0
3250	3.6	77.7	21.6
2926	5.8	61.1	10.6

Table 18. RELATIONSHIP BETWEEN (ORGANICS) AND PROTEIN

ANCHORAGE A

Sample No.	Protein	Acetone Soluble (Organics)	Acetone Soluble (Organics) / Protein
173	1.8	13.5	7.5
174	3.7	18.9	5.1
175	2.4	34.1	14.2
172	4.7	20.1	4.3
161	1.5	12.1	8.1
162	2.8	12.1	4.3
163	2.1	19.6	9.3
164	2.0	18.0	9.0
171	2.2	17.0	7.7
165	1.4	23.4	16.7
170	1.5	13.8	9.2
169	0.9	11.3	12.6
168	0.7	12.5	17.8
167	1.9	31.0	16.3
166	1.4	24.8	17.8
2212	1.4	26.1	18.7
2211	1.5	15.5	10.3
2210	2.0	20.5	10.2
2219	2.2	19.1	8.7